

# Linear Reciprocating Propulsion Apparatus

## TECHNICAL FIELD

The present invention relates to a driving apparatus that is characterized by single endless chain and manually powered linear propulsion, mainly used for securely-sustained non-motorized vehicle or vessel.

## BACKGROUND OF THE INVENTION

Vehicles and vessels need power driving. Manually powered devices are commonly used in non-motorized wheel vehicle, among which some have linear reciprocating driving mechanics for the purpose of substituting walking rather than entertaining or exercising.

Chinese Pat. No. 99108216.8 (CN1275511A) forwarded a bicycle with linear path of movement. It has a toothed rack driven mechanism affixed on a tilted square frame with two toothed racks in a sliding groove. Depression of either pedal will cause rack to move, draw sprocket wheel and chain and transfer the power to rear driving wheel. A reset gear is used for reset control.

Related patents are US,A,6129646 (Farmos); US,A,5236211 (Meguerditchian); Fr,A,2544052(MICHAUDETG); US,A,4169609 (Zsmpedro); US,A,3891235 (Shelly). All the above-mentioned patents employ a plurality of endless chain mechanism and two members shall run alternately. Their structures are much complicated and there are also great difficulties in processing and installation.

Chinese Pat. No. 99123093.0 (CN1298824A) forwarded a bicycle with rotatable crank. Its driving mechanism adopts two prime cranks on the left and right for pedal driving. The rear end of crank is connected with the crank end of rear wheel with driven crank linking in between, drives a small sprocket and form secondary transmission together with coaxial large sprocket, and finally transmitted to the driving shaft of rear wheel. It also belongs to approximately linear path of movement but with too many transmission links and reduced efficiency.

My Chinese Patent (Application No. 01132621.2) discloses "tractive chain bicycle" including the structure of wire rope traction. However, the wire rope will curl in the course of small pulley transmitting torque and the curl will affect normal operation. In addition, the mechanics sometimes fail in reversing.

Obviously, the mechanics with linear force applied shall first ensure its smooth continuous running as well as the convenience of processing, especially avoiding overmany transmission links and idle run so as to improve transmission efficiency.

## **DISCLOSURE OF INVENTION**

The present invention refers to a tractive linear driving apparatus with good integration and structure which is applicable to equipping with manually-powered carriers. The apparatus features considerable flexibility in the design of applying force, great leeway for R & D and higher transmission efficiency.

The present invention of tractive linear reciprocating driving apparatus consists of a solid frame, a movable member having a slipping module incorporating an engaging and reversing mechanics and transmission members of single endless chain, sprocket wheel and flywheel. The shaft of flywheel outputs power and forms mechanical transmission.

This tractive linear reciprocating driving apparatus comprises slipping module, slave engaging and reversing mechanics, flywheel, driven sprocket, chain and guide column, it has:

A frame that consists of guide column, auxiliary frame column and frame endplates, the ends of frame are affixed with flywheel and driven sprocket with a single endless chain installed and linked in between, its guide column and auxiliary frame column used for directional linear sliding are installed on the side of chain ring plane; a slipping module for linear driving and slave engaging and reversing mechanics is installed on the guide column; the upper and lower slide bars of the slipping module mounted on the guide column slide upwards and downwards along the guide column, pedal and handpower rod are used to apply force to butt plates on both sides of slipping module;

It is characterized by:

1) The said slave engaging and reversing mechanics has an engagement means located in the plane of chain ring; upper and lower slave slide bars connected with the said engagement means is mounted on the guide column; engaging toothed bar is provided in the engagement means, strained end is float-connected with slipping module and connecting pieces that consist of pull-up rod, pull-down rod and connecting rod; the toothed bar in said engagement means has two teeth to engage said chain on both directions working jointly with both chain-retaining board and chain and activating alternately with teeth in each direction.

2) A reversing compensation means is designed for slave engaging and reversing

mechanics that comprises a resilient member contacting the front of chain tooth directly or indirectly in opposite direction, and a space or clearance is left for movement.

The said reversing compensation means is mobile mechanics for the purpose of elastic contact on or beneath slave sprocket and its arm may contact the front of chain tooth of slave sprocket elastically under the action of said resilient member. To check chain tooth, said arm may press chain tooth under the action of spring and realize smooth reverse, and serve as a considerable buffer.

The said reversing compensation means is a modified single-stage flywheel in which there is a structural member for transmission between leaf spring and chain tooth, leaf spring props up the rear end of jack to make it elastically contact first the front of ladder type rackets and then the front of chain tooth of outer hull indirectly.

The tractive linear reciprocating driving apparatus of this invention has the following vigorous effects:

1. Since it adopts single endless chain structure, the driving apparatus of this invention has a more compact structure and more convenience in processing and installation. In application, the whole apparatus can be installed directly in combination with driving wheel and axle of vehicle or boat. Linear applying of force has higher efficiency. Even if adding secondary chain drive, the effect is also quite good;

2. This driving apparatus is used mainly for equipping exercising apparatus, giving prominence to the feature of convenient and natural method of applying force. Since simultaneously stepping with foot and pulling with hand in operation, comprehensive exercising effect can be obtained. It is applicable to one-man, two-man or multi-man manually-powered vehicle and boat, as well as communication means or sports;

3. Since slipping module can suit the change of different angles of force applied hereto, more designing space to meet different seating postures can be obtained to satisfy various needs in applications and products;

4. Since it is more suitable for installing in securely-sustained vehicle or boat, this apparatus has the features of convenience, safety and comfort. It can be operated even in chair and suitable for the old and weak for entertainment.

## Brief Description of Drawings

Fig. 1 is a structural diagram of this invention.

Fig. 2 is a top view of the structure delineated by line A-A.

Fig. 3 is a structural diagram of swing toothed bar for chain engagement.

Fig. 4 is a structural diagram of reversing compensation means.

Fig. 5 is a structural diagram of directly-moved toothed bar for chain engagement.

Fig. 6 is a structural view of another type of slipping apparatus.

Fig. 7 is a structural diagram of reversing compensation means integrated with follower wheel.

Fig. 8 is a structural schematic diagram of one-man driven tricycle in the first embodiment.

Fig. 9 is a top view of the embodiment in Fig. 8.

Fig. 10 is a structural diagram of two-man driven tricycle in the second embodiment.

Fig. 11 is a structural diagram of amphibian bicycle in the third embodiment.

In the above-mentioned drawings:

1. frame 2. flywheel 3. chain 4. slipping module 5. pedal 6. handpower rod  
7. guide column 8. driven sprocket 9. sprocket support 10. reversing compensator  
11. auxiliary frame pillar 11A. guide tongue 12. upper slide bar of slipping module 13.  
pull-up rod 14. chain engagement means 15. slave engaging and reversing mechanics  
16. slave upper slide bar 17. chain-retaining board 18. slave lower slide bar 19. chain  
engaging toothed bar 20. lower slide bar of slipping module 21. pull-down rod 22. nose  
of connecting rod 23. front butt plate of slipping module 24. rear butt plate of slipping  
module 25. transitional coupling plate 26. bottom plate of chain engagement means  
27. short shaft 28. hole to connect rod nose 29. chain-engaging teeth 30. limit pin  
31. chain-engaging teeth 32. hanged plate 33. groove frame 34. positioning hole  
35. tension spring 36. strong compressed spring 37. arm 38. arm shaft 39. damp  
spring leaf 40. guide groove 41. jogger 42. guide rail of plate column form 43. chute  
44. chain tooth 45. leaf spring 46. chute wall 47. compensation clearance 48. mobile  
crown 49. jack spring 50. jack 51. ladder type ratchet 52. steel ball 53. seat  
54. carriage 55. regulating wheel 56. foot-controlled rudder mass 57. driving wheel  
58. follower wheel 59. handlebar 60. rod handle 61. connecting rod 62. main (rear)  
buoy 63. side buoy 64. front buoy 65. impeller

## Detailed Description of the Preferred Embodiment

A better understanding of the invention will be obtained by referring to the accompanying drawings in which:

Fig. 1 illustrates a tractive linear reciprocating driving apparatus given by this invention. It comprises a frame 1 that consists of guide column 7, auxiliary frame 11 and frame endplates. Connected to one end of frame is flywheel 2 with driving sprocket and to another end is a slave sprocket 8 with the same diameter, with a single endless chain installed in between, its guide column and auxiliary frame column installed on the side of chain ring plane (backwards in the figure); a slipping module 4 and slave engaging and reversing mechanics 15 are installed on the guide column; frame may be installed in different ways for the different applications, and can be installed in the appropriate position of vehicle or boat through connecting pieces. In this embodiment, the upper and lower slide bar 12, 20 of the slipping module mounted on the guide column 7 slide upwards and downwards along the guide column with guide tongue 11A; pedal 5 and handpower rod 6 are affixed to rear butt plate of slipping module so as to apply force with foot and hand; the chain engagement means 14 in said slave engaging and reversing mechanics works in the plane of chain ring, chain engagement means 14 is connected with upper and lower slave slide bar 16, 18 and mounted together on guide column 7. In the chain engagement means 14 is provided a chain engaging toothed bar 19 that is float-connected by pull-up rod, pull-down rod, nose of connecting rod and slipping module, follows up the upward or downward movement of slipping module and controls the activity of chain engaging. In the figure, flywheel 2 -- the driving sprocket to output power, turns the force applied thereto in linear way to shaft torque to operate the driving wheel. Chain-retaining board 17 with an arc projection to retain chain is used to limit the position of chain in reversing and guarantee said tooth to engage chain smoothly. Reversing compensation means 10 guarantees smooth operation of slave engaging and reversing mechanics. As shown in the figure, a chain-tensioning device is provided on sprocket support to adjust the tensioning of chain by drawing slave sprocket shaft; existing structure of bicycle chain tensioning is adopted for this embodiment.

Fig. 2 illustrates a diagrammatic top view of this invention. Underneath is bottom plate of frame 1, guide column 7 and auxiliary frame pillar 11 stand on both sides, pedal 5 is on the left connecting front butt plate of slipping module 23, 24 and lower slide bar 20, chain engagement means 14 is shown in cross sectional view comprising chain engaging toothed

bar 19, pull-down rod 21 and flywheel hidden underneath. Chain engagement means 14 connects upper and lower slave slide bars with transitional coupling plate 25. As shown in the figure, slave lower slide bar 18 and lower slide bar of slipping module 20 matches with the jaw at guide tongue 11A on the right. The relation of connection between lower slide bar 20 and two butt plates 23, 24 of slipping module incorporating handpower rod 6 and pedal 5 is shown manifestly.

Fig. 3 illustrates the structure of chain engaging module in said chain engagement means 14. It belongs to a swing chain engaging mechanism. Chain engaging toothed bar 19 is fixed on bottom plate 26 by short shaft 27 with a hole 28 to connect rod nose, when being drawn upwards and downwards, swings and reverses the chain to engage. There are two chain-engaging teeth 29, 31 towards both directions on said chain engaging toothed bar 19, together with chain-retaining board 17 with chain-retaining arc projection, jointly match with chain 3 and are alternately activated to perform automatic slave reversing. 30 is a limit pin.

The course of slave reversing control is as follows: when nose of connecting rod 22 is drawn downwards, chain-engaging teeth 31 will insert in chain on the left to carry said chain to go downwards; when drawn upwards, chain-engaging teeth 31 will disengage said chain and chain-engaging teeth 29 will insert in chain on the right to carry said chain to go upwards. 30 is a limit pin.

Fig. 4 illustrates the reversing compensation means installed on the lower part of slave sprocket on the frame. The hanged plate 32 of said device is connected with slave sprocket 8 by coaxial coupling, arm 37 is rotatable around arm axle 38 in hanged plate 32, upper arm end makes straightforward contact with sprocket teeth, lower arm end contacts a tension spring 35, enabling upper arm end to contact sprocket tooth front directly and always activate said tooth front. In reversing of direction, when lower engaging toothed bar 19 moves towards opposite side, a compensation motion in opposite direction occurs to solve the problem that toothed bar cannot insert in chain hole for an instant, and ensure smooth reversing. Strong compressed spring 36 acts as a buffer in the course of reversing direction. 38 is arm axle for securing. Positioning hole 34 is used for adjusting mounting position. 39 is damp spring leaf. 33 is groove frame for securing.

Fig. 5 illustrates another embodiment of chain engaging toothed bar with directly motion structure. Chain engaging toothed bar reverses in guide groove 40 and joggers 41 are added.

Fig. 6 illustrates another embodiment of guide column structure where 4 is slipping

module and slave chain engaging and reversing mechanics are also located. 42 is guide rail of plate column form and 43 is chute.

Fig. 7 illustrates a reverse compensation means modified from single-stage flywheel of existing bicycle. It has dual functions of slave sprocket and flywheel. The figure shows a part of flywheel case in which 44 is chain tooth in outskirts of outer hull that incorporates ladder type ratchet 51 in the inner margin of said outer hull, ball path with steel balls installed is on both sides of said ratchet; a jack 50 (chaplet) props up the inside of said ratchet to force outer hull only to be in unidirectional rotation. Jack spring 49 (chaplet spring) forces said jack to prop up always in working condition. Flywheel base and bottom cover plate form an inner hull installed on drive shaft. Flywheel originally performs pure circular motion and needs no reversing or compensation. To adapt the reversing for this tractive linear reciprocating driving apparatus, a mobile crown 48 is added in jack groove of inner hull between original jack and the fixed block to bear said jack, leaving an appropriate clearance 47 for reversing compensation. 46 is chute wall. A leaf spring 45 is provided behind said mobile crown, bending when said jack props up said ratchet. This compensator uses solid inner hull, the leaf spring thereof rebounds and props up said jack to provide a compensation shift in opposite direction in reversing, carries out the insertion of the teeth of toothed bar in chain hole during said shift so as to avoid instant failing of insertion and guarantee a smooth reversing.

Fig. 8, 9, 10 and 11 are embodiment of three different applications of this invention.

Fig. 8 and 9 illustrate structure of the same one-man manually-powered tricycle that comprises carriage 54, regulating wheel 55, driving wheel 57, follower wheel 58, pedal 5, seat 53, handlebar, transmission and brake devices. Traditional mechanism is used for brake device. Driving wheel is in the right front, regulating wheel is in the behind, and driving apparatus is installed on the carriage before seat. Connected to driving apparatus 1 are pedal, rod handle 60, handlebar 59 and foot-controlled rudder mass 56 with double foot positions. In this embodiment, hands and feet can be used simultaneously, with one foot controlling direction. On the basis of this embodiment, two-man manually-powered tricycle can be simply developed by widening carriage and seat. Traditional brake can also be used.

Hereunder explains the working procedure of tractive linear reciprocating driving apparatus of this invention as shown in the embodiment of said one-man tricycle:

1. After riding on seat, control regulating wheel with one foot, step with the other foot, grip rod handle to be ready for lifting and hold handlebar with the other hand.

2. When stepping, slipping module 4 goes directly downwards, driven by nose of connecting rod 22, pull-down rod 21 enables chain-engaging teeth 31 of chain engaging toothed bar 19 to insert in the left chain; while continuously applying force, flywheel 2 runs and driving wheel rotates to drive the tricycle forwards (to the left in the figure);

3. When lifting the rod with hand, slipping module 4 goes directly upwards, pull-up rod 13 is driven to enable chain-engaging teeth 29 of chain engaging toothed bar 19 to insert in the right chain; while continuously applying force, flywheel 2 runs in original direction and driving wheel rotates to drive the tricycle forwards (to the left in the figure);

4. When stopping applying force in stepping with foot and lifting with hand, the tricycle keeps running forward by inertia;

5. Repeat above-said operation of stepping with foot and lifting with hand, the tricycle keeps running forward.

Fig. 10 illustrates an embodiment of another kind of fore-and-aft two-man tricycle. Regulating wheel 55 is designed in the left front, driving wheel 57 is on the right side in the middle, follower rear wheel 58 is provided on the left side of rear seat, namely, front and rear wheels are on the same side and driving wheel in the middle is on the other side. Two fore-and-aft seats are designed. The front rider controls the direction and joins stepping with foot; connecting rod 61 imparts driving power to slipping module. The rear rider mainly pulls the rod to apply force. Two riders alternately apply force to jointly drive the tricycle forward. If necessary, rear rider can help applying force with stepping. In fact various two-man embodiment may be designed utilizing the driving apparatus of this invention, such as the type of rear regulating wheel, double driving apparatus in the same direction, face-to-face type with single or double driving apparatus and 4-wheel type with single or double driving apparatus.

Fig. 11 illustrates a structural representation of amphibious bicycle that incorporates carriage 54 and wheels, with driving apparatus 1 tilting forwards. To suit application in water, an impeller 65 driven by chain drive is designed in upper front with a draft of  $1/4 \sim 1/6$  impeller diameter. Three pairs of buoy are set in front, middle and rear carriage on left and right sides. They are respectively front buoys 64, side buoys 63 and main (rear) buoys 62. Side buoys 63 are fixed on both sides of carriage with supporting litter that incorporate hinges to retract buoys. The buoys at position B, C and D are omitted in one side in the figure.



To sum up, many products with different structures can be developed utilizing the driving apparatus of this invention. Such arrangements also include: adding secondary chain drive, utilizing leverage or hydraulic transmission, multiple driving apparatus and different seating posture. Since there may be many varieties, this invention has an excellent future of application.